

Sensory maps in the olfactory cortex defined by long-range viral tracing of single neurons.

Journal:	Nature
Publication Year:	2011
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PubMed link:	21451523
Funding Grants:	Generating pluripotent cell lines from neurons., Curriculum Development and Implementation of Stem Cell Technology and Laboratory Management Emphasis in an Established MS Biotechnology and Bioinformatics Program at California State University Channel Islands and Co-development of a GE Course on Stem Cel

Public Summary:

Sensory information may be represented in the brain by stereotyped mapping of axonal inputs or by patterning that varies between individuals. In olfaction, a stereotyped map is evident in the first sensory processing centre, the olfactory bulb (OB), where different odours elicit activity in unique combinatorial patterns of spatially invariant glomeruli. Activation of each glomerulus is relayed to higher cortical processing centres by a set of approximately 20-50 'homotypic' mitral and tufted (MT) neurons. In the cortex, target neurons integrate information from multiple glomeruli to detect distinct features of chemically diverse odours. How this is accomplished remains unclear, perhaps because the cortical mapping of glomerular information by individual MT neurons has not been described. Here we use new viral tracing and three-dimensional brain reconstruction methods to compare the cortical projections of defined sets of MT neurons. We show that the gross-scale organization of the OB is preserved in the patterns of axonal projections to one processing centre yet reordered in another, suggesting that distinct coding strategies may operate in different targets. However, at the level of individual neurons neither glomerular order nor stereotypy is preserved in either region. Rather, homotypic MT neurons from the same glomerulus innervate broad regions that differ between individuals. Strikingly, even in the same animal, MT neurons exhibit extensive diversity in wiring; axons of homotypic MT pairs diverge from each other, emit primary branches at distinct locations and 70-90% of branches of homotypic and heterotypic pairs are non-overlapping. This pronounced reorganization of sensory maps in the cortex offers an anatomic substrate for expanded combinatorial integration of information from spatially distinct glomeruli and predicts an unanticipated role for diversification of otherwise similar output neurons.

Scientific Abstract:

Sensory information may be represented in the brain by stereotyped mapping of axonal inputs or by patterning that varies between individuals. In olfaction, a stereotyped map is evident in the first sensory processing centre, the olfactory bulb (OB), where different odours elicit activity in unique combinatorial patterns of spatially invariant glomeruli. Activation of each glomerulus is relayed to higher cortical processing centres by a set of approximately 20-50 'homotypic' mitral and tufted (MT) neurons. In the cortex, target neurons integrate information from multiple glomeruli to detect distinct features of chemically diverse odours. How this is accomplished remains unclear, perhaps because the cortical mapping of glomerular information by individual MT neurons has not been described. Here we use new viral tracing and three-dimensional brain reconstruction methods to compare the cortical projections of defined sets of MT neurons. We show that the gross-scale organization of the OB is preserved in the patterns of axonal projections to one processing centre yet reordered in another, suggesting that distinct coding strategies may operate in different targets. However, at the level of individual neurons neither glomerular order nor stereotypy is preserved in either region. Rather, homotypic MT neurons from the same glomerulus innervate broad regions that differ between individuals. Strikingly, even in the same animal, MT neurons exhibit extensive diversity in wiring; axons of homotypic MT pairs diverge from each other, emit primary branches at distinct locations and 70-90% of branches of homotypic and heterotypic pairs are non-overlapping. This pronounced reorganization of sensory maps in the cortex offers an anatomic substrate for expanded combinatorial integration of information from spatially distinct glomeruli and predicts an unanticipated role for diversification of otherwise similar output neurons.